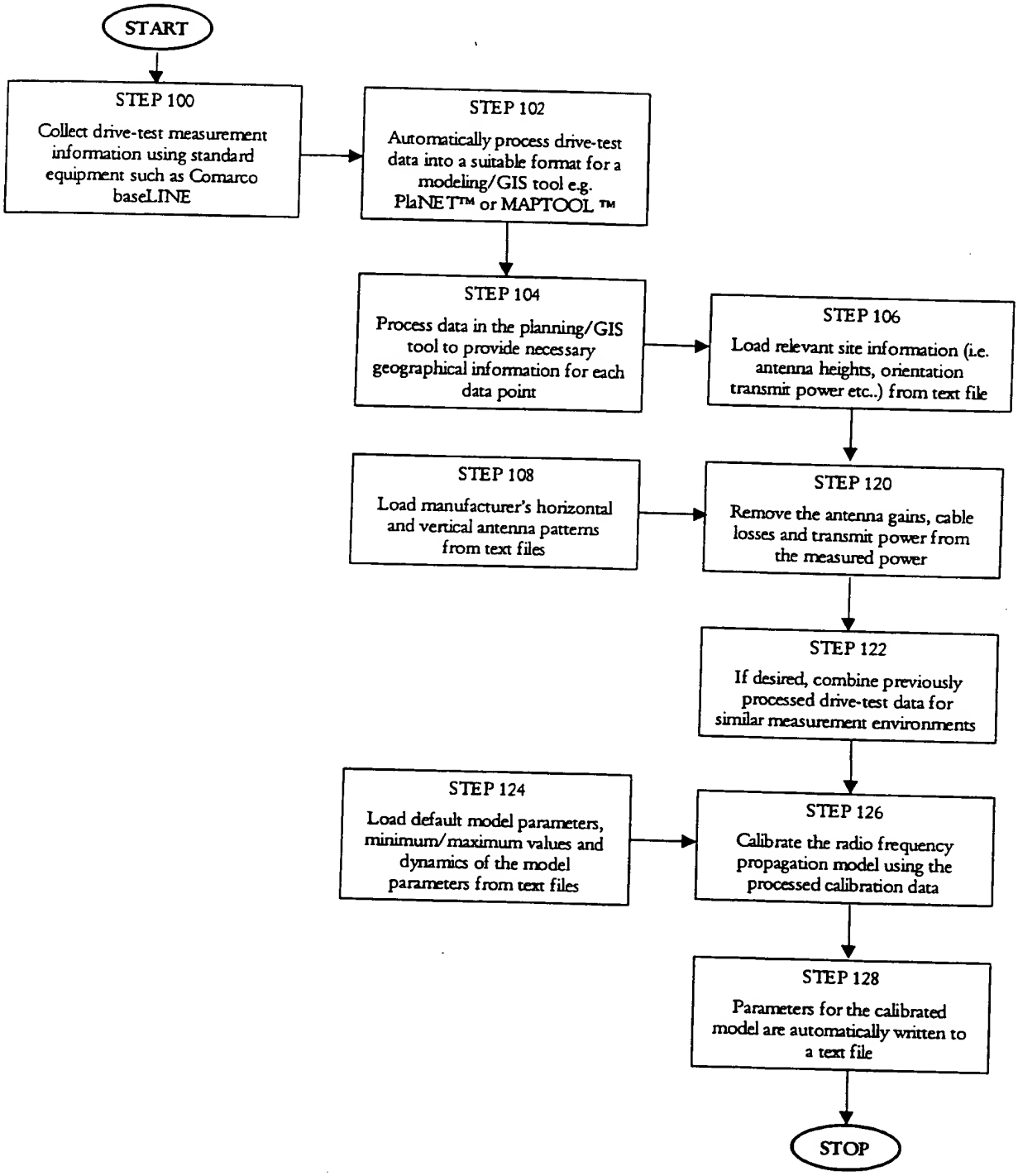

START
STEP 100
Collect drive-test measurement information using standard equipment such as Comarco baseLINE
STEP 102
Automatically process drive-test data into a suitable format for a modeling/GIS tool e.g. PlaNET™ or MAPTOOL ™
STEP 104
Process data in the planning/GIS tool to provide necessary geographical information for each data point
STEP 106
Load relevant site information (i.e. antenna heights, orientation transmit power etc..) from text file
STEP 108
Load manufacturer's horizontal and vertical antenna patterns from text files
STEP 120
Remove the antenna gains, cable losses and transmit power from the measured power
STEP 122
If desired, combine previously processed drive-test data for similar measurement environments
STEP 124
Load default model parameters, minimum/maximum values and dynamics of the model parameters from text files
STEP 126
Calibrate the radio frequency propagation model using the processed calibration data
STEP 128
Parameters for the calibrated model are automatically written to a text file
STOP

FIGURE 1

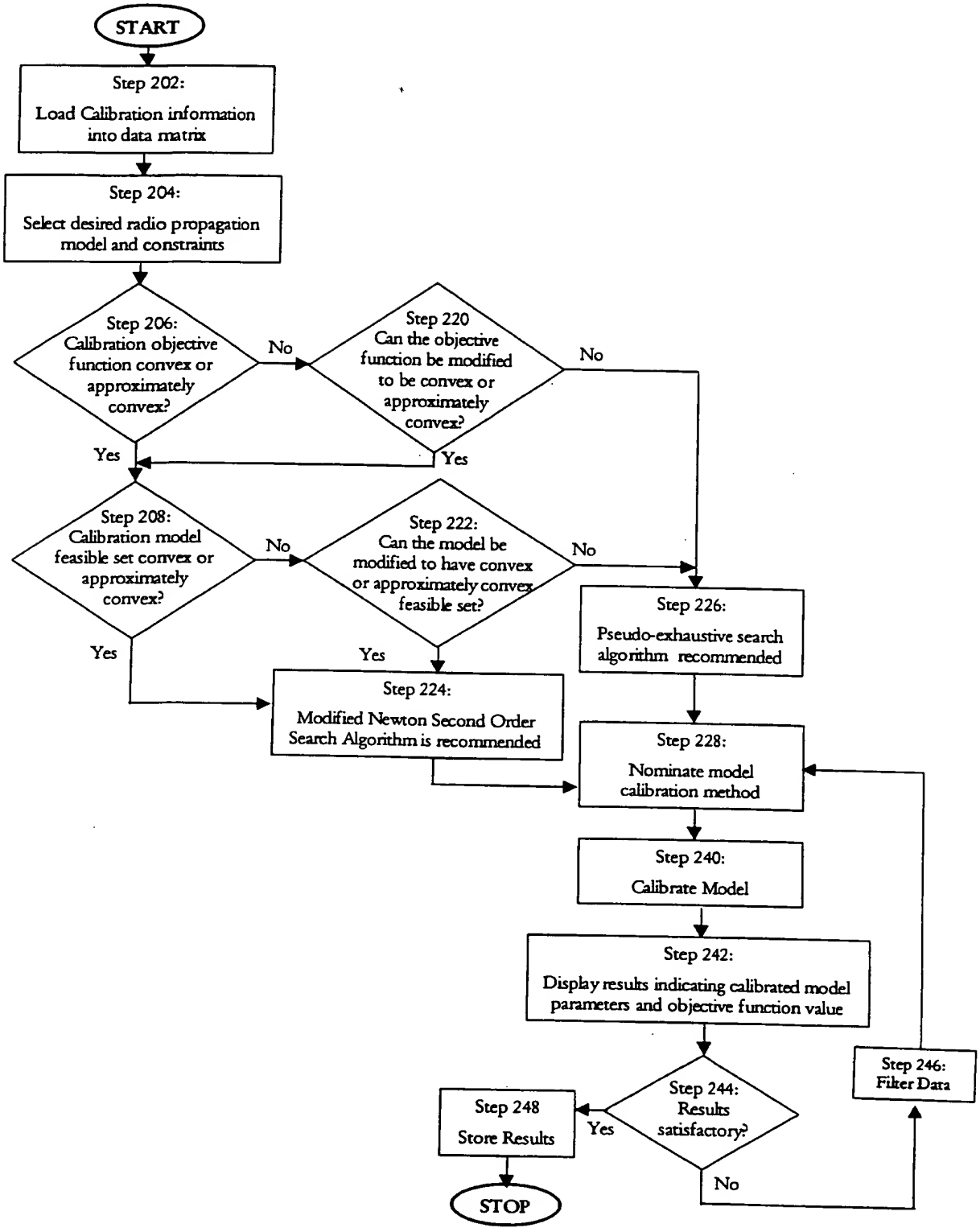

START
Step 202:
Load Calibration information into data matrix
Step 204:
Select desired radio propagation model and constraints
Step 206:
Calibration objective function convex or approximately convex?
No
Step 220
Can the objective function be modified to be convex or approximately convex?
No
Yes
Yes
Step 208:
Calibration model feasible set convex or approximately convex?
No
Step 222:
Can the model be modified to have convex or approximately convex feasible set?
No
Yes
Yes
Step 226:
Pseudo-exhaustive search algorithm recommended
Step 224:
Modified Newton Second Order Search Algorithm is recommended
Step 228:
Nominate model calibration method
Step 240:
Calibrate Model
Step 242:
Display results indicating calibrated model parameters and objective function value
Step 244:
Results satisfactory?
Yes
Step 248
Store Results
STOP
No
Step 246:
Filter Data

FIGURE 2

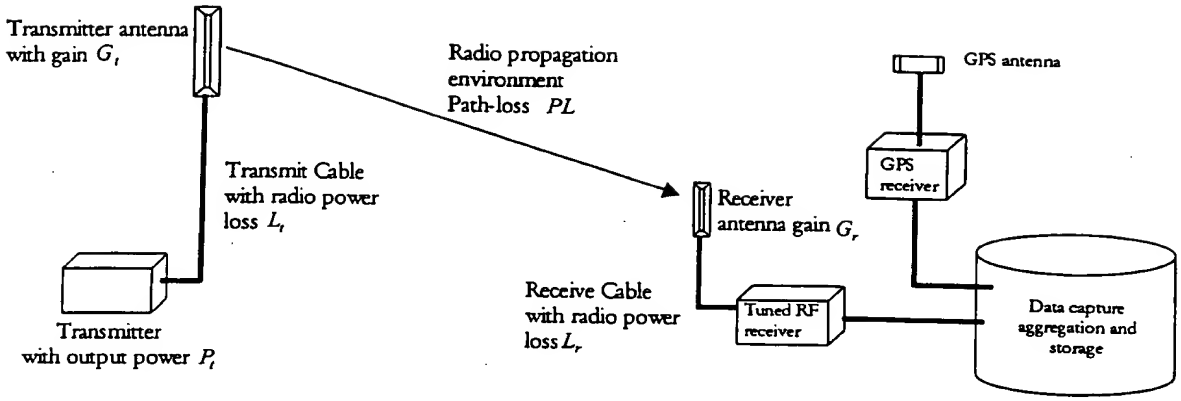

Transmitter antenna
with gain G_t
Radio propagation
environment
Path-loss PL
GPS antenna
GPS
receiver
Transmit Cable
with radio power
loss L_t
Receiver
antenna gain G_r
Receive Cable
with radio power
loss L_r
Tuned RF
receiver
Data capture
aggregation and
storage
Transmitter
with output power P_t

FIGURE 3

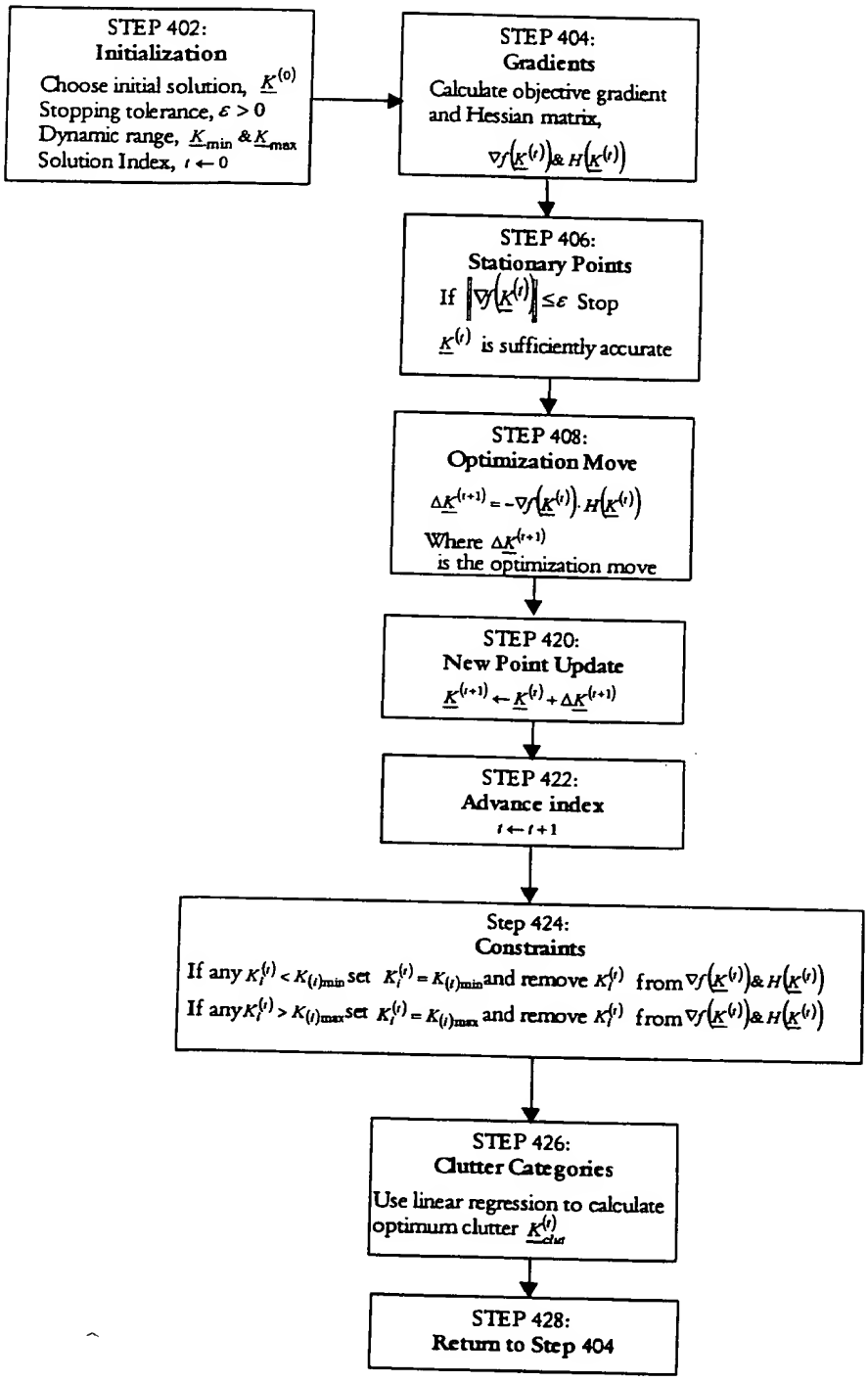
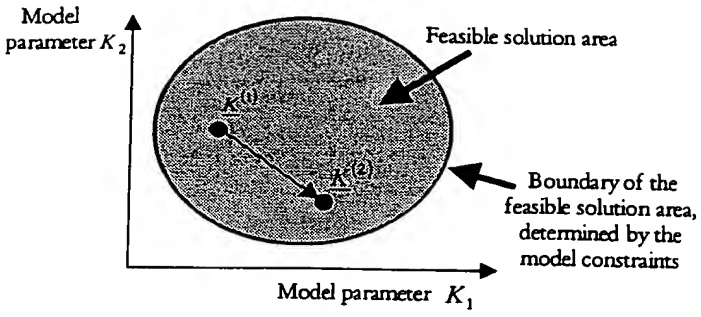
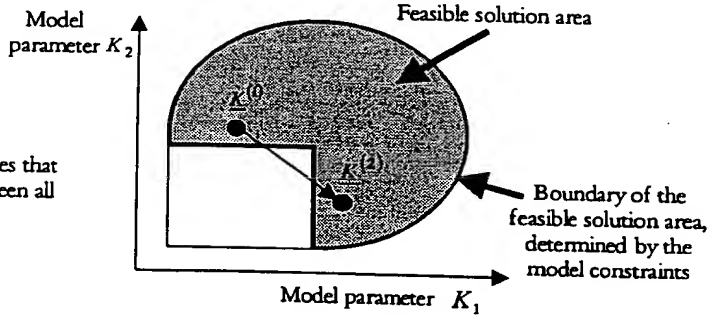

STEP 402:
Initialization
Choose initial solution, $\underline{K}^{(0)}$
Stopping tolerance, $\varepsilon > 0$
Dynamic range, $\underline{K}_{min}$ & $\underline{K}_{max}$
Solution Index, $t \leftarrow 0$
STEP 404:
Gradients
Calculate objective gradient and Hessian matrix,
$\nabla f(\underline{K}^{(t)})$ & $H(\underline{K}^{(t)})$
STEP 406:
Stationary Points
If $\|\nabla f(\underline{K}^{(t)})\| \leq \varepsilon$ Stop
$\underline{K}^{(t)}$ is sufficiently accurate
STEP 408:
Optimization Move
$\Delta\underline{K}^{(t+1)} = -\nabla f(\underline{K}^{(t)}) \cdot H(\underline{K}^{(t)})$
Where $\Delta\underline{K}^{(t+1)}$ is the optimization move
STEP 420:
New Point Update
$\underline{K}^{(t+1)} \leftarrow \underline{K}^{(t)} + \Delta\underline{K}^{(t+1)}$
STEP 422:
Advance index
$t \leftarrow t+1$
Step 424:
Constraints
If any $K_i^{(t)} < K_{(t)min}$ set $K_i^{(t)} = K_{(t)min}$ and remove $K_i^{(t)}$ from $\nabla f(\underline{K}^{(t)})$ & $H(\underline{K}^{(t)})$
If any $K_i^{(t)} > K_{(t)max}$ set $K_i^{(t)} = K_{(t)max}$ and remove $K_i^{(t)}$ from $\nabla f(\underline{K}^{(t)})$ & $H(\underline{K}^{(t)})$
STEP 426:
Clutter Categories
Use linear regression to calculate optimum clutter $\underline{K}_{clut}^{(t)}$
STEP 428:
Return to Step 404

FIGURE 4



Demonstrates a **convex feasible set**, which implies that any solution within the feasible set can be reached from any other solution in the feasible set.



Demonstrates a **non-convex feasible set**, which implies that there is no guarantee of being able to move freely between all solutions within the feasible set.

FIGURE 5

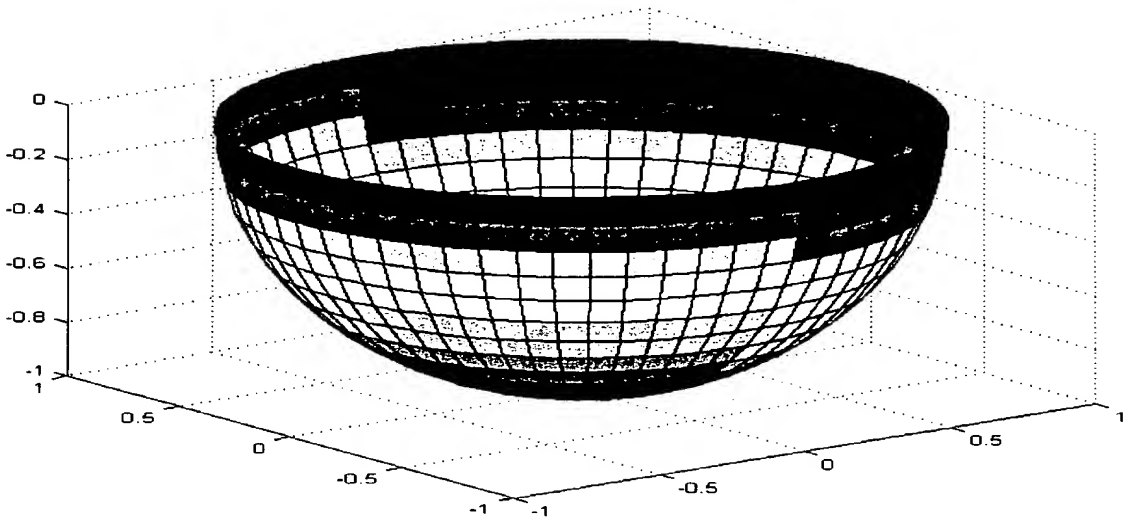


FIGURE 6

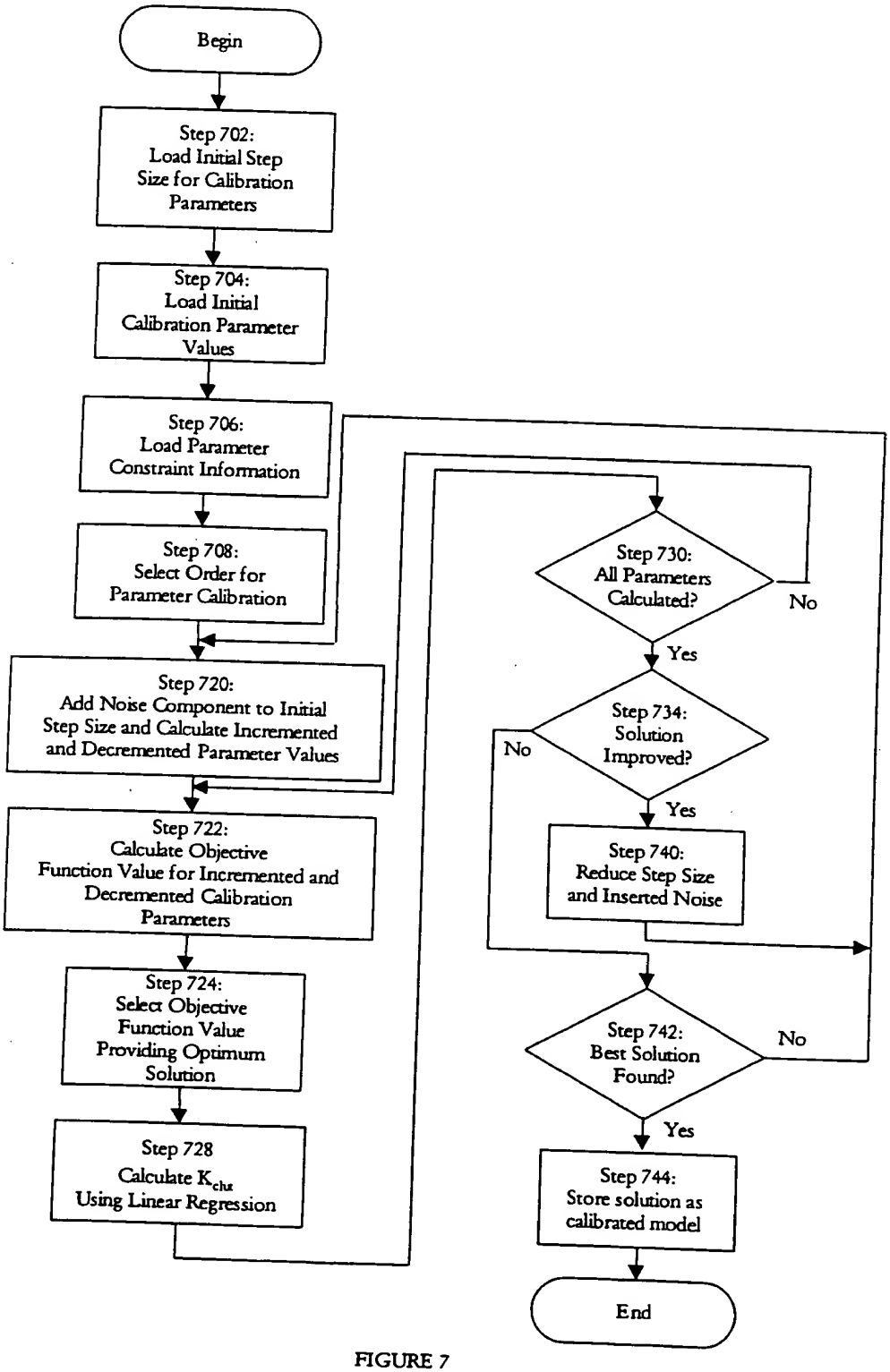
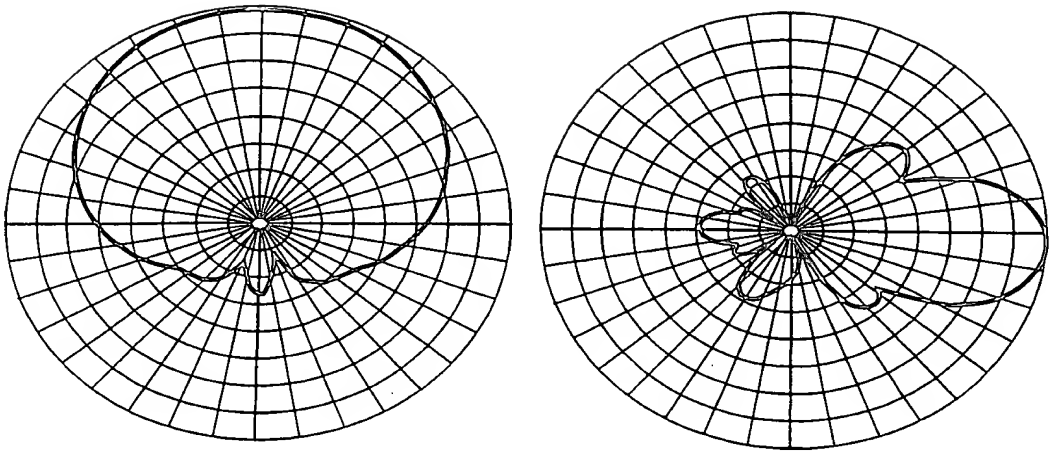

Begin
Step 702: Load Initial Step Size for Calibration Parameters
Step 704: Load Initial Calibration Parameter Values
Step 706: Load Parameter Constraint Information
Step 708: Select Order for Parameter Calibration
Step 720: Add Noise Component to Initial Step Size and Calculate Incremented and Decremented Parameter Values
Step 722: Calculate Objective Function Value for Incremented and Decremented Calibration Parameters
Step 724: Select Objective Function Value Providing Optimum Solution
Step 728 Calculate K_{chz} Using Linear Regression
Step 730: All Parameters Calculated?
No
Yes
Step 734: Solution Improved?
No
Yes
Step 740: Reduce Step Size and Inserted Noise
Step 742: Best Solution Found?
No
Yes
Step 744: Store solution as calibrated model
End

FIGURE 7



H-plane (Horizontal) pattern

E-plane (Vertical) pattern

FIGURE 8

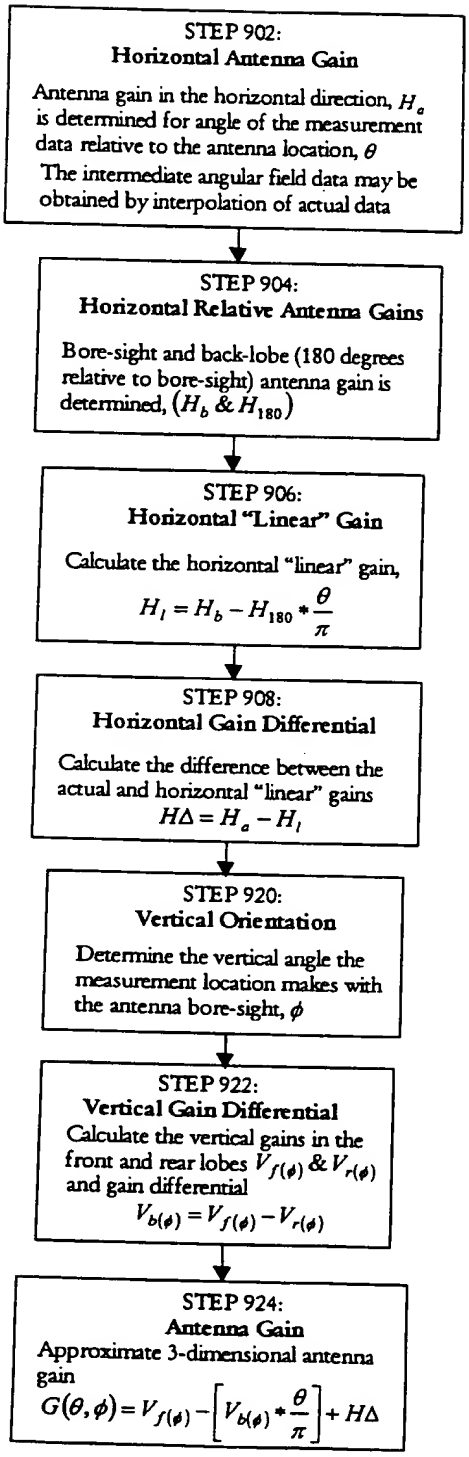

STEP 902:
Horizontal Antenna Gain
Antenna gain in the horizontal direction, H_a is determined for angle of the measurement data relative to the antenna location, θ
The intermediate angular field data may be obtained by interpolation of actual data
STEP 904:
Horizontal Relative Antenna Gains
Bore-sight and back-lobe (180 degrees relative to bore-sight) antenna gain is determined, $(H_b \& H_{180})$
STEP 906:
Horizontal "Linear" Gain
Calculate the horizontal "linear" gain,
$H_l = H_b - H_{180} * \frac{\theta}{\pi}$
STEP 908:
Horizontal Gain Differential
Calculate the difference between the actual and horizontal "linear" gains
$H\Delta = H_a - H_l$
STEP 920:
Vertical Orientation
Determine the vertical angle the measurement location makes with the antenna bore-sight, ϕ
STEP 922:
Vertical Gain Differential
Calculate the vertical gains in the front and rear lobes $V_{f(\phi)} \& V_{r(\phi)}$ and gain differential
$V_{b(\phi)} = V_{f(\phi)} - V_{r(\phi)}$
STEP 924:
Antenna Gain
Approximate 3-dimensional antenna gain
$G(\theta,\phi) = V_{f(\phi)} - \left[V_{b(\phi)} * \frac{\theta}{\pi}\right] + H\Delta$

FIGURE 9

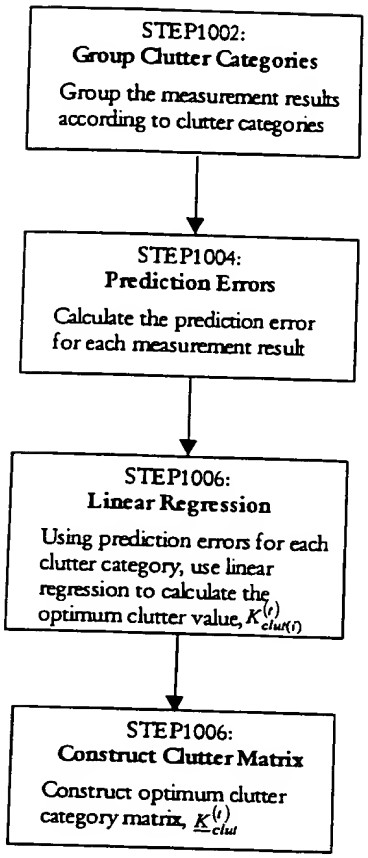

STEP1002:
Group Clutter Categories
Group the measurement results according to clutter categories
STEP1004:
Prediction Errors
Calculate the prediction error for each measurement result
STEP1006:
Linear Regression
Using prediction errors for each clutter category, use linear regression to calculate the optimum clutter value, $K^{(t)}_{clut(i)}$
STEP1006:
Construct Clutter Matrix
Construct optimum clutter category matrix, $\underline{K}^{(t)}_{clut}$

FIGURE 10


Step 1102
Select Site
Step 1104
Configure
Equipment
Step 1108
Drive
Test Route
Step 1120
Save Data

FIGURE 11